Neutrinos at BNL
Rationale and Goals

Presented to the
BNL Neutrino Workshop

by
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Upton, NY
March 3, 2004

Office of Science
U.S. DEPARTMENT OF ENERGY

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Plan of the Talk

- The Very Long Baseline Neutrino Experiment concept and rationale
- VLB Neutrino Beam from Brookhaven AGS
- Detector considerations from BNL's point of view
- BNL Goals in Neutrino Physics & DOE-NSF Connections
- Conclusions

Rationale for the VLB Neutrino Experiment

- the goal of this method is to determine *all* the unmeasured neutrino oscillation parameters using a single beam and experimental detector
- a *Very Long Baseline, Wide-Band Neutrino Beam* from Brookhaven's AGS accelerator (suitably upgraded) can provide the needed beam
- a Neutrino Detector located deep underground in the Rocky Mountains or in the Black Hills can provide a suitable detector for this experiment
- such a Neutrino Detector is natural in scale for advancing the physics reach in the search for nucleon decay and other cosmic neutrino phenomena (eg. *UNO*)
- the VLB proponents believe that the BNL concept is unique in the world for its combination of *existing accelerator capability* and *geographical advantage* for accomplishing these goals at minimum cost

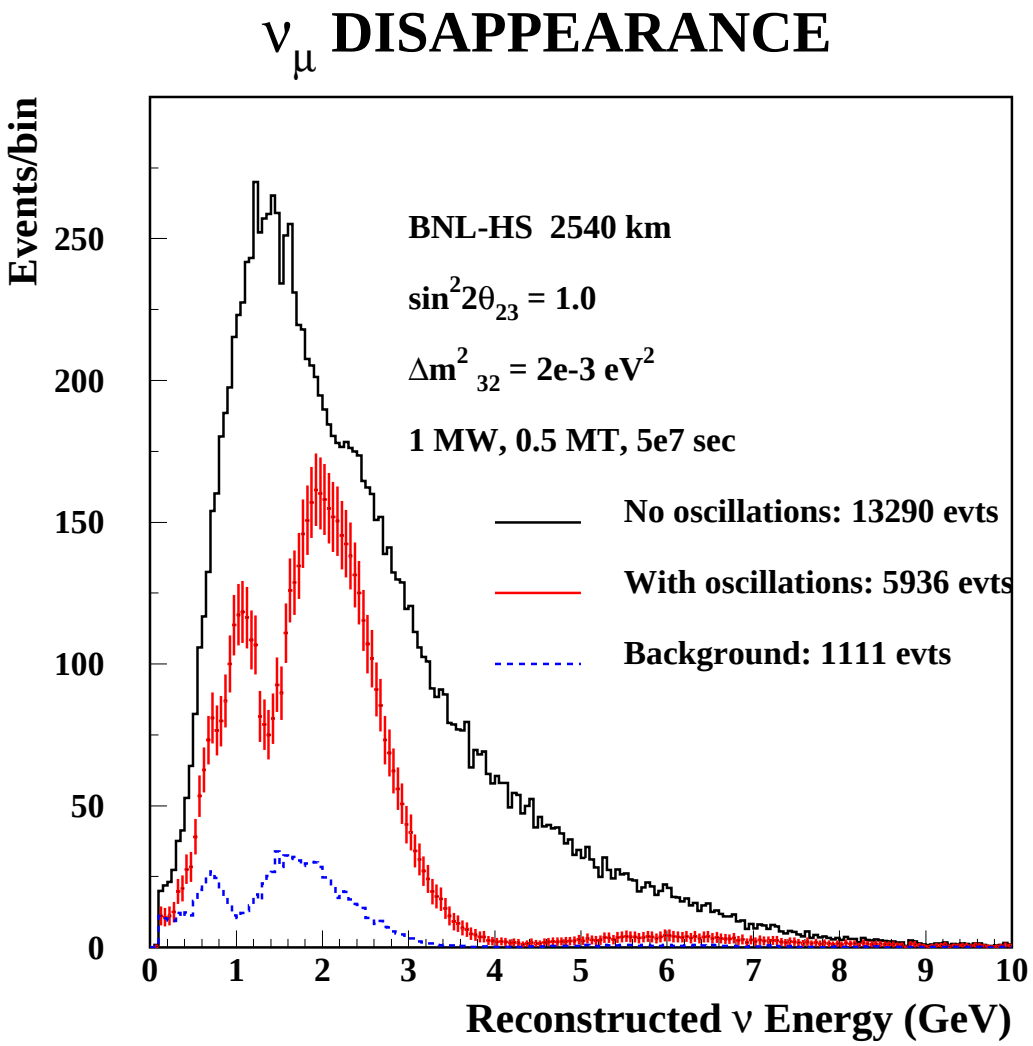
Physics Goals of the Very Long Baseline Neutrino Program

We introduce a plan to provide the following goals in a ***single facility***:

- precise determination of the oscillation parameters Δm_{32}^2 and $\sin^2 2\theta_{23}$
- detection of the oscillation of $\nu_\mu \rightarrow \nu_e$ and measurement of $\sin^2 2\theta_{13}$
- a measurement of $\Delta m_{21}^2 \sin^2 2\theta_{12}$ in a $\nu_\mu \rightarrow \nu_e$ appearance mode can be made even if the value of θ_{13} is zero
- verification of matter enhancement and the sign of Δm_{32}^2
- determination of the CP-violation parameter δ_{CP} in the neutrino sector

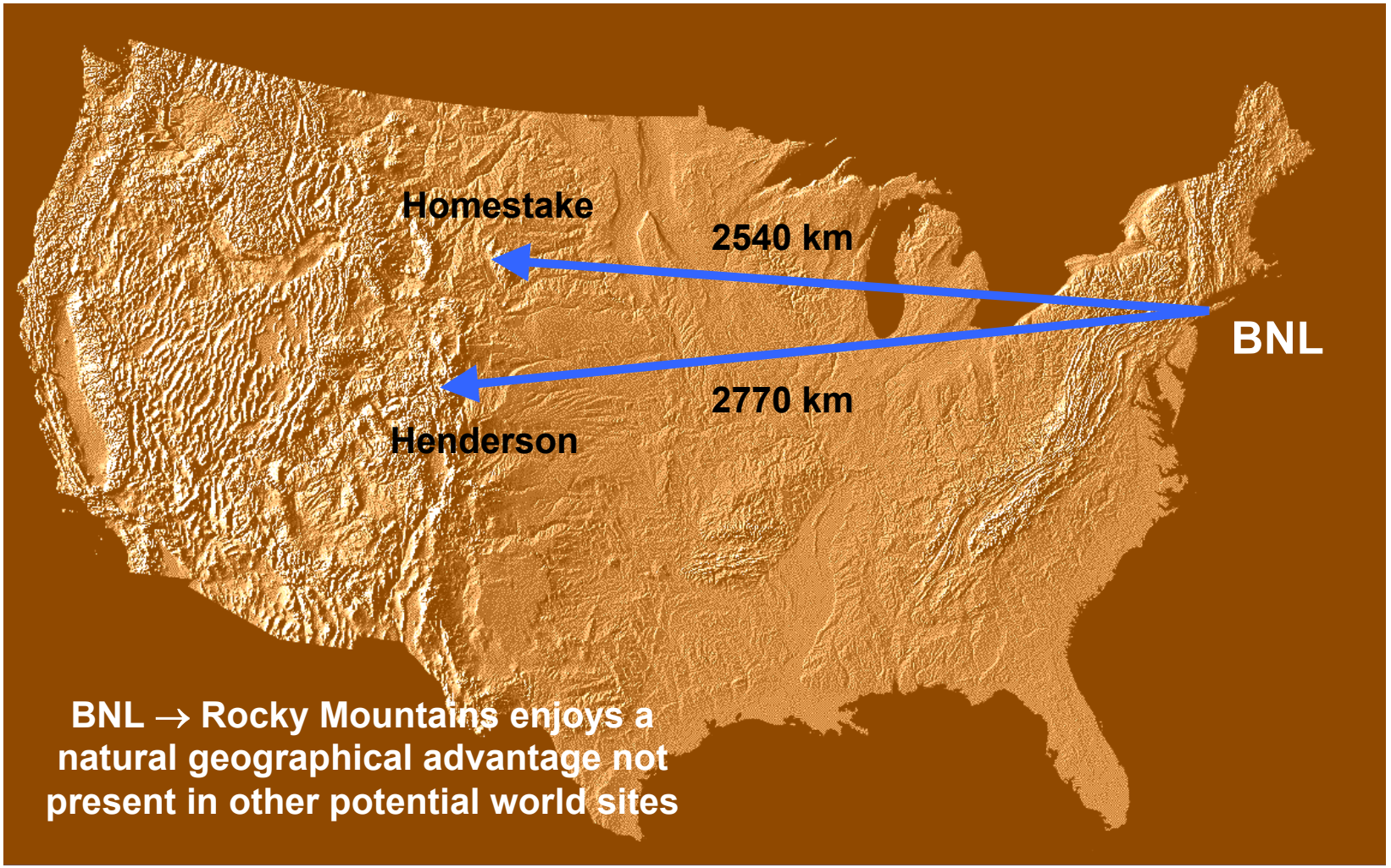
The use of a *single neutrino super beam source* and *half-megaton neutrino detector* will optimize the efficiency and cost-effectiveness of a full program of neutrino measurements. If the value of $\sin^2 2\theta_{13}$ happens to be larger than ~0.01, then all the parameters, including CP-violation can be determined in the VLB program presented here. If not, anti-neutrino running can be done

Advantages of a Very Long Baseline

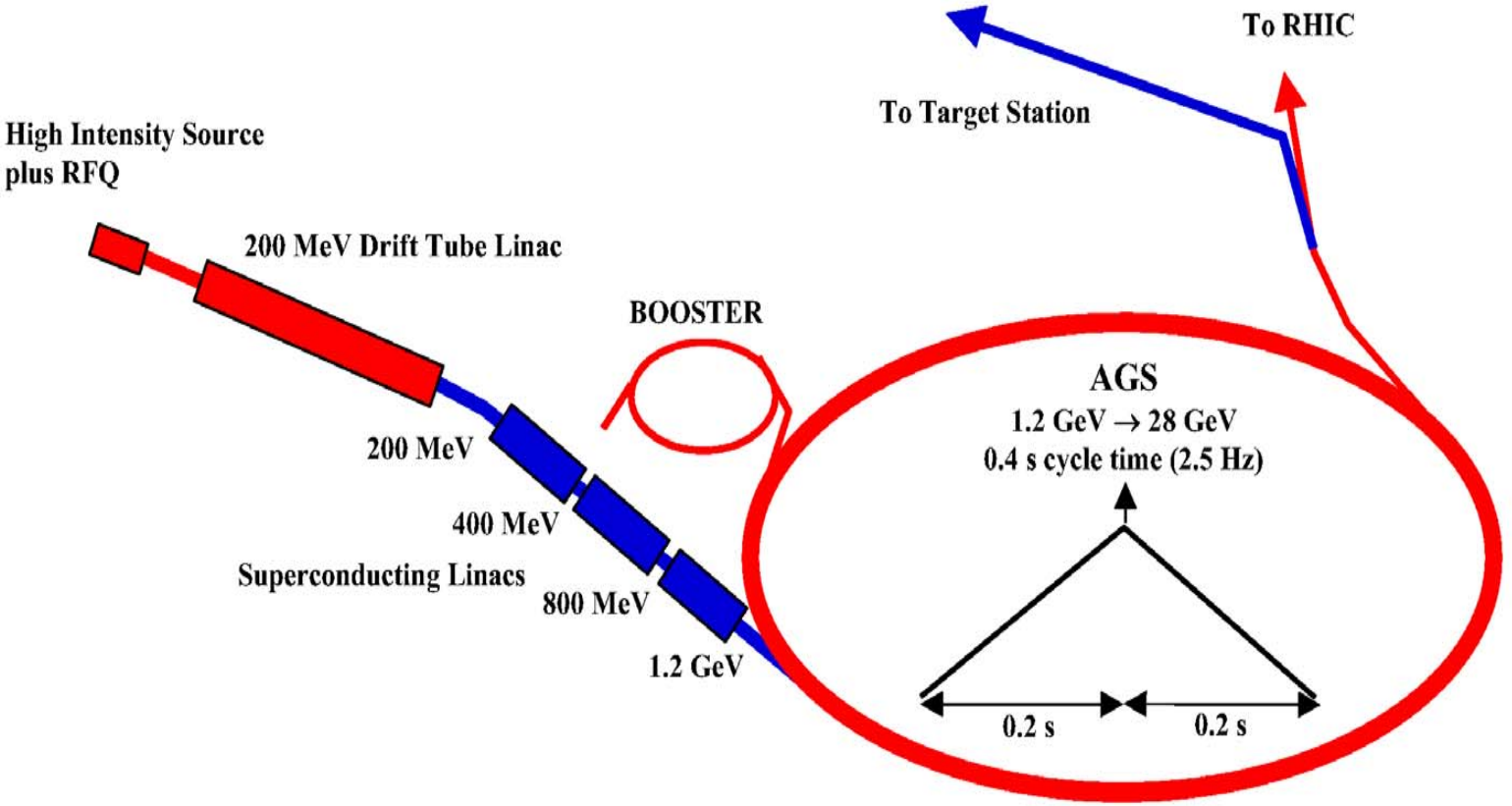


- neutrino oscillations result from the factor $\sin^2(\Delta m^2_{32}\ L / 4E)$ modulating the ν flux for each flavor (here ν_μ disappearance)
- the oscillation period is directly proportional to distance and inversely proportional to energy
- with a *very long baseline* actual oscillations are seen in the data as a function of energy
- the multiple-node structure of the very long baseline allows the Δm^2_{32} to be precisely measured by a *wavelength* rather than an amplitude (reducing systematic errors)

BNL → Rocky Mountains Super Neutrino Beam

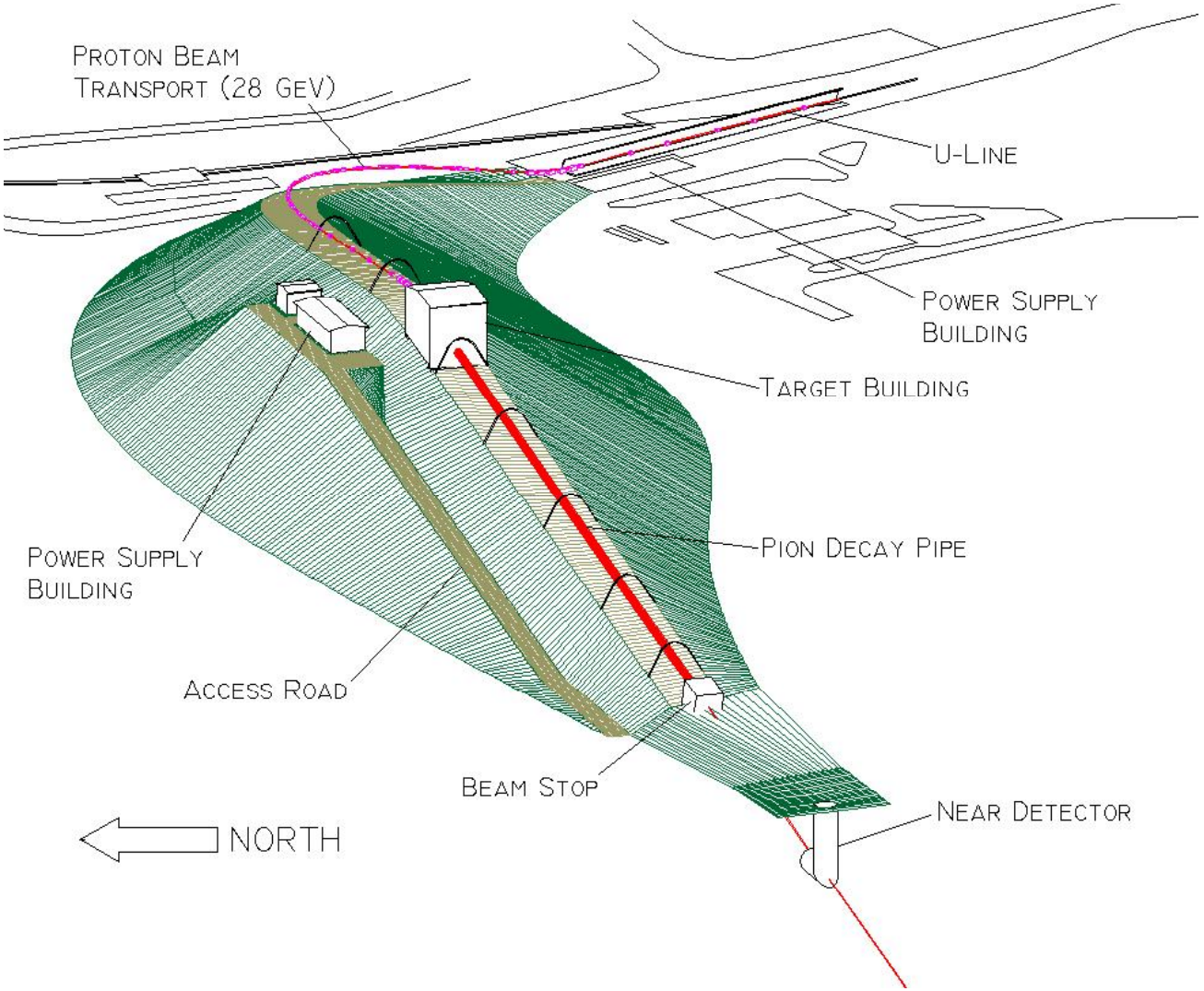


AGS Target Power Upgrade to 1 MW



- the *AGS Upgrade* together with the *1.0 MW Super Neutrino Beam* has an estimated cost of $369M FY03 (TEC) dollars

3-D Neutrino Super Beam Perspective



BNL Views on the VLB Neutrino Detector

- the experimental detector for the VLB Neutrino Experiment will need to be in the 0.05 – 0.5 Mtonne mass range, depending on technology
- the *UNO Detector* (0.5 Mtonne) is a credible detector for VLB, plus it meets the requirement for a strong step ahead in nucleon decay sensitivity as well as other possible astrophysical applications
- a second, potentially credible detector approach, would employ a *LAr Detector* (in the 0.1 Mtonne class), trading detector mass for usable, exclusive physics processes to do both neutrino and nucleon decay
- a very massive Neutrino Detector, deep underground, is a natural physics anchor for the contemplated *National Underground Laboratory* still in very active contemplation by the National Science Foundation
- BNL is involved in the *detector R&D program* and will support the emerging detector concept that best meets the overall science goals

Conclusions

- measurement of the *complete set of neutrino mass and mixing parameters* is very compelling for the advance of particle physics
- the *Very Long Baseline* method, utilizing a *1 MW Super Neutrino Beam* from BNL's AGS, coupled with a *megaton-class Neutrino Detector* in the Rocky Mountains/Black Hills, offers a uniquely effective approach
- NSF approval and funding prospects for the success of a National Underground Laboratory are positive and the *VLB Neutrino Experiment* is a strong candidate for inclusion in the baseline scope of the DUSEL scientific program
- BNL intends to compete actively for the VLB Neutrino Experiment and expects to promote an *upgraded AGS Super Neutrino Beam* as the most cost-effective source for the needed neutrino beam to accomplish this extremely important advance in worldwide particle physics